

MANNED MARS MISSION CREW FACTORS

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ABSTRACT

Crew factors include a wide range of concerns relating to the human system and its role in a Mars mission. There are two important areas which will play a large part in determining the crew for a Mars mission. The first relates to the goals and priorities determined for such a vast endeavor. The second is the design of the vehicle for the journey. The human system cannot be separated from the other systems in that vehicle. In fact it will be the human system which drives the development of many of the technical breakthroughs necessary to make a Mars mission successful. As much as possible, the engineering systems must adapt to the needs of the human system and its individual components.

INTRODUCTION

By far the most complicated and perhaps the most unpredictable system involved in a manned Mars mission will be the HUMAN system. This paper will discuss some considerations relating to that system: that is, crew selection, size, and composition and other relevant crew factors for a mission to Mars.

The human system cannot function without considering other systems that would be involved in such a complicated mission. For that reason, the makeup of the crew for the Mars journey will largely depend on a number of important factors. Perhaps the most important consideration will be: what will be the overall goals of a Mars Mission? Are we going just "to get there and back again safely"? This is obviously not a trivial goal, but it is a different matter if the goal were to be "to get there and accumulate as much data, do as many experiments, and explore as much of the Martian surface as possible or lay ground work for a future outpost, then return safely to Earth. In the former case, a smaller and less scientifically trained crew might suffice, while in the latter situation a larger more diverse crew with different scientific specialties would probably be required.

Prior to landing on the Moon, NASA was able to "practice" sending crews nearly to the Lunar surface without landing them just to test all

the necessary maneuvers that were required for a Lunar landing. It was also known in advance that there would be other Apollo missions (after Apollo 11) landing on the Moon and therefore, the scientific objectives could be split up among all the missions. But what if we had only one chance--one mission to land on the Moon? While the Moon is hundreds of thousands of miles away from our Earth, compared to millions for a mission to the Martian surface, it is literally, "next door."

HABITABILITY

The importance of designing efficient man-machine systems has long been accepted since it was recognized that optimal integration increased the efficiency of the human's interaction with the machine and therefore decreased error (1-4). These issues of habitability become extremely important on longer duration space endeavors. Attention to environmental detail and real productivity may be an important factor in helping a Mars crew deal with the stress inherent in a Mars mission.

Jones [5] and Johnson [6] have discussed the major aspects of habitability which will be relevant to the design of any vehicle intended to take humans to Mars. These include: (1) environment--including atmosphere, temperature, lighting, and radiation levels; (2) architecture--how the living space is arranged; (3) mobility, restraints, and equipment handling; (4) food--i.e., preparation and storage; (5) clothing; (6) personal hygiene--body waste collection and grooming; (7) house-keeping--refuse, cleaning, and laundering; (8) communication--intravehicular only; and (9) off-duty activity provisions--exercise, Earth contact, and entertainment. Santy [7] has suggested that continued communication between crew members and their families, allocation of space for individual mementos (e.g. pictures and items with sentimental attachment), time for off-duty creative activities (such as painting, writing or gardening), and the option of being alone, (i.e. having space designed to allow individuals to be by themselves) will be extremely important for crewmembers on a long-duration space voyage.

MEDICAL FACTORS IN CREW SELECTION

Certainly all individuals selected to be crewmembers on a Mars voyage would have to be in excellent health. However, the unique aspects of a mission of such long duration have certain other implications relating to health. Since the mission will most likely be two years or

longer, careful consideration will have to be given to those disease processes which a specific individual might have a higher than usual chance of developing, particularly those which might incapacitate the individual or possibly prove fatal in the space environment. On the long journey to Mars, even simple medical problems which are easily treated here on Earth, might become potentially life-threatening. An example of this would be appendicitis, in which simple surgical removal of the inflamed appendix is usually curative. But in space, when the individual is hundreds of thousands of miles away from an operating room, there is no agreed upon way at the present time that such surgery can be done in space; nor could the ill crewmember be treated palliatively and brought home. Our screening process then for the Mars trip might well include a requirement that the individual have already had his appendix removed. Other medical considerations for exclusion might include positive family histories of certain diseases (which at the moment are not disqualifying) such as myocardial infarction, alzheimers, diabetes, and certain types of cancer. At the very least, individuals with these family histories should be more carefully looked at and their own risk factors determined. It might be important also that women who are being considered should be sufficiently well-protected against the possibility of becoming pregnant, or be beyond her childbearing years.

Of course we cannot anticipate all potential problems, but there are some which we might avoid altogether if we have the proper screening.

Another area of medical considerations for a manned Mars mission are the specific psychological factors which might help an individual endure the long journey. A high degree of maturity and experience would definitely be desirable. In this context, the psychological profiles of the early space pioneers may not be the best of psychological guidelines for determining crew selection on an extended-stay mission. Those persons who need constant stimulation might not necessarily perform well when confined to a small, isolated environment for long periods of time [8-9]. On the other hand, it has been suggested that chosen individuals should have to deal with a minimum of separation stresses; i.e., that they not have minor dependent children (10). Again all of these points argue for individuals over the age of 45 as being ideal candidates for an early Mars crew.

COMPOSITION OF CREW

A lunar landing was planned around a crew of three---all of them pilots. Certainly several pilots and engineers will need to be on the Mars crew. In addition, probably a physician/life scientists will be required. Then several physical scientists--possibly a geologist, geophysicist or planetologist. Possibly a physicist, astronomer, or astrophysicist would also be good choices.

Individuals will have to have some overlap in knowledge. This will be particularly important in trans-Mars science activities and in the operational area--such as the piloting/navigation duties, since if one person became incapacitated there would be someone else to perform those assignments crucial to bringing the crew back to Earth.

Should there be "mixed" crew--that is both men and women? Having crewmembers of both sexes could potentially raise some problems on a long-duration mission, specifically regarding issues of sexuality. Of course this is a very individual and personal area, but there are no research data to guide us in decisionmaking. The experience at the U. S. Antarctic camp is also very limited since only a few women have stayed over during the long winter when the camp is completely isolated from the outside world [11]. It would be worthwhile to contact these women and their male associates and obtain their perspective on the specific stresses or problems that arose for them in that isolated environment, since they may well be relevant to mixed crews on a Mars mission.

There is no reason why a Mars mission should not have women crewmembers working side by side with their male colleagues. Although this is a sensitive area, there is time to look into it and develop some recommendations. One possible idea is that the Mars crew be made up of married couples. However, this only looks at one part of the sexuality issue [12]. McGuire [13] has suggested that on any crew for a long-duration mission there should be at least two women (or two men), and not just one since the stresses imposed (including further psychological isolation) might be very difficult to deal with. This might be a useful principle to apply in other areas rather than just for the gender issue. For example, it is possible that a Mars mission might be an international venture and a multinational crew might be considered. Psychologically speaking, it might be wise to always have at least two individuals from

any country so as to decrease the problem of severe psychological isolation. On the other hand, it would not be useful or efficient to have a crew which is broken up into small cliques. Both of these factors would have to be weighed carefully.

Other considerations for crew composition will have to depend on the specific mission goals.

LEADERSHIP ISSUES

Some decision will have to be made regarding how leadership is to be structured on a Mars mission. First, who will have ultimate authority--the ground control or the individuals in space? As far as the crew structure, is democracy the best policy? Or is some kind of authoritarian/military system more efficient? There will probably be a mixture of political, military, and scientific goals for a Mars mission. Should there be separation of "military" and "scientific" personnel [8]?

If a small crew (i.e. less than five) were chosen to go to Mars, it is possible that a more "military" style of leadership might work best. On the other hand, a larger crew might require a more democratic style. Obviously, arguments can be made for exactly the reverse of the above. The Soviet experience in this regard is interesting. Several cosmonauts have commented that they got along much better interpersonally if leadership was shared [14]. This was in situations where there were only two or three cosmonauts together on the Russian Space Station. Clearly, this is an area which requires further study. It would be important to look at groups with different leadership styles to see which ones are able to perform group goals in the most efficient and harmonious manner in other isolated environments. While efficiency is very important, the ability of the crew to get along with each other will be crucial for a long journey. In the space environment, there will be no place to go to "get away from it all," and interpersonal conflict may result in behavior that threatens the entire crew. This must be prevented if at all possible.

The type of leadership style which might be best for a Mars mission will also depend on the specific mission goals for such a mission.

SIZE OF CREW

Again, the number of individuals on a Mars crew will in large part depend on the specific mission goals and on the size of the vehicle(s)

that will be used. However, there are a number of points to consider in this area. Bluth [15] for example, has suggested that there should be an odd number of crewmembers for such a voyage. "Experience has shown that even numbers of people under stress tend more often to split into two equal and opposing camps, unable to reach a democratic solution to urgent mission decisions."

Too many individuals may not be efficient or economically feasible. However, too few might lead to overwork and a lack of necessary overlap in crew duties which would increase the hazards of the mission quite extensively. However many individuals are on the mission, it is essential to keep in mind the habitability factors mentioned previously. Individuals can deal with severe discomfort, crowding and lack of privacy for reasonable periods of time if their motivation remains high, but even short intervals of time in those conditions will take a great physical and psychological toll. The Mars crewmembers must be able to expect a reasonable degree of comfort and privacy during their two year voyage to Mars.

SUMMARY

Specific crew considerations for a mission to Mars will depend on the goals that are set for the mission and on the limitations of the vehicle designed for the journey. The human system and its unique problems and potentials must be integrated into the vehicle engineering systems in order to maximize the ability of the crew to carry out mission goals.

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